Preservation and Restoration of Authenticity in Sound Recordings

WALTER L. WELCH

THIS REVIEW of the state of the art of preservation and restoration of authenticity in sound recordings is based on research conducted at the Syracuse University Audio Archives, and Thomas Alva Edison Foundation Re-Recording Laboratory. The archives and the laboratory are part of the resources of Syracuse University Libraries. The laboratory is concerned with historic truth in the re-presentation of audio materials to students and researchers, a function entirely consistent with a university library's interest in guiding its users to the best sources of information.

The laboratory is interested not only in the preservation and restoration of authenticity in historical material, but also in problems concerning the extent to which current sound recordings truthfully represent the world of sound, and the extent to which modern artifacts will survive the vicissitudes of time and use. This article will discuss both historical problems against the background of the development of phonography and certain aspects of the current use of audio technology.

The spoken word conveys its own unique version of truth: it expresses emotion, meaning and emphasis which cannot be reproduced with complete accuracy in any graphic medium. Until the invention of the phonograph, speech—the simplest, most efficient, and by far the fastest means of communication ever devised by man—was evanescent, dependent on the memory of the listener. Music without words, except for certain formal features involving the intellect, is almost pure emotion. Therefore, the timbre of the spoken voice, the singing voice, and the subtle intonations of musical instruments are of great importance. Therefore, the authentication of sound depends on its reproduction free of disturbing or diluting effects produced by ambient conditions

Walter L. Welch is Curator and Director, Syracuse University Audio Archives, and Thomas Alva Edison Foundation Re-Recording Laboratory.

in the recording or reproducing environment. Moreover, the recording process should be precisely inverse to the reproducing process, the level of sound reproduced should not be greater than that produced by the original voices and/or instruments.

Many sophisticated sound-measuring instruments have been devised, but so far they have been applied only to the testing of components of modern electronic devices; they have not been used to provide overall evaluations of record-reproduce systems to establish inverse relationships so sorely needed today. Conceding the usefulness of sound measuring devices, none has yet been developed which surpasses the acuity and discriminatory capability of the ear. This was demonstrated some time ago when, with the use of highly sophisticated sound measuring devices, it was proclaimed (erroneously) that a modern violin made of aluminum duplicated the tone of a Stradivarius. The ear has the capacity to distinguish the tone of one Stradivarius from another; the world's great violinists still prefer the tone of these instruments made so long ago by the craftsmen of Cremona which have fortunately, along with other great musical instruments, survived into the present. But what has been the fate—since the rise of phonography—of the recorded performances of these instruments? How well have they survived?

Preservation for posterity has been a goal since the earliest days of phonography. Unfortunately, as with the goal expressed so enthusiastically in advertising the Edison gold-molded cylinders, "As Loud and Clear as the Original," these high ideals have not been followed to satisfactory conclusions. Working with museums and libraries, one is constantly reminded of the tremendous gap between early aspirations and extent of fulfillment, at least as far as historical truth and educational usefulness are concerned.

Librarians know how much research and scholarship depend on preservation of primary sources which store and transmit information through the visual media of print and the written word. For audio information, in whatever form, the primary sources are not the recordings alone, but also the mechanisms used to record and reproduce them. What is or has been written about them is at least secondary.

At the laboratory, work is being done with artifacts of the recording industry: the records, and the instruments designed to record and reproduce them. Neither sufficient time nor money has been available to research the considerable literature which exists—principally theses, papers in the technical journals, and articles intended for the layman in the more popular periodicals—but this research should be done. The difficulty is that these sources are secondary and, in all cases, competent research requires access to the primary sources, the artifacts.

Work in the laboratory has been largely empirical. However, there has been some work done with scientists interested in this field. The initial effort has been to direct attention to the marvelous technology which has been developed by various laboratory's inventors, who have worked in the interests of the conservation of recorded history, as well as of the shareholders in various commercial enterprises.

What is the state of the art of sound recording? How well have the sound recording industries served history and education in the past. How well do the diversified and sophisticated audio devices serve the causes of historic truth today? These questions require answers before one can realistically choose the record-reproduce systems appropriate for educational needs today. Furthermore, libraries cannot afford to squander their limited financial resources; the conservation of all their resources, including audio and visual materials, must receive high priority. How well does the recording industry serve this need? The answer is: Not very well. Those libraries desiring to maintain the high frequency fidelity of long-playing or stereo discs find it necessary to copy them onto high quality reel-to-reel tape if they wish to insure availability to scholars and historians of the future.

The Thomas Alva Edison Foundation Re-Recording Laboratory has been engaged primarily in finding ways to re-record obsolete cylinders and discs to quality standards for reproduction through modern media. However, the rapidly growing number of forms in which recordings are offered to the public, and the lack of overall criteria of tonal fidelity in modern sound systems present a grave problem. The record industry, through its advertising media, would have everyone believe that it is at the summit of true high fidelity in the reproduction of sound, but this simply does not bear analysis.

In research libraries, silence is an essential requisite to thoughtful study. Thus many libraries provide stereo headsets for listening. It would be a great aid to the understanding of the spoken word and music to hear recordings with the two ears as nature designed them to be used—with a slightly different sound pattern received by each ear via lightweight earphones which do not disturb anyone else. A successful library listening room, using only cylinder records and eartube listening apparatus, existed in Paris at the turn of the century. The recordings were monophonic, and any difference in the sound pattern delivered to each ear was coincidental, not intentional. Sound recordings with earphones operate no more scientifically accurately today. For the most part, records presently available are stereophonic—recorded with the principal microphones widely spaced to create an illusion of reality when the sound is reproduced through speakers spaced six to eight feet apart. What is heard via headsets is often clearly false (although often surprisingly agreeable); however, in most instances when a stereo disc is used, it is inaccurate and deceptive.

As in the visual phenomenon of stereoscopy which makes use of the natural duality of human vision, stereophony pertains to the natural duality of human hearing. Most contemporary earphone listening systems are essentially binaural—a differing signal is delivered to each ear. However, to deliver the truth about a given performance, ideally two microphones would be spaced only six inches apart, separated by a divider and oriented to collect sound as do the human ears. Only two microphones and two channels should be employed in the entire process. Many, if not most, stereo discs and tapes are recorded from sixteen-channel tape recorders, and the engineers and tape editors—not the composer, and seldom the conductor—determine what the eventual mix for a stereo disc or tape will be.

Stereo is an illusion, but there is no need for it to be a misleading one, which it has generally become. The quality of sound currently given the public is often larger and more glorious than ever could be obtained under the best acoustical conditions for a live performance. Performers who try to compete with recordings have the unattainable goals of perfection which never would be possible but for the genius of clever tape editors who make one performance of many. Sound technology is moving into quadrasonics in discs, and multi-channel reproduction in stereo which will be, indeed, the never-never land. How scholars of the future will be able to disengage the voice of a great singer from the welter of sounds collected by sixteen microphones, mixed and saturated with untold reflection patterns, is unkown.

Great art deserves better. The ironic aspect is that the equipment to record and reproduce binaural sound accurately for tapes or discs is comparatively inexpensive, so that music and drama schools and libraries can make authentic sound available. In fact, a new market for such recordings would be at hand—the schools of fine arts and music education and, eventually, a truly discriminating public. If only two of the sixteen channels on the master recording tapes were recorded accurately as a control, and for future binaural interpretation, there would be a valuable criterion for verification of the future work of engineers.

This method would be analogous to the present desire and ability to search out the truth in the early cylinder recordings by means of stethoscopic phenomena, used for quality in the original studios.

Early inventors of phonographic devices recognized the need for definite reproducing mechanisms for which to design records and by which to judge their quality. The principal device for judging the quality of musical cylinders from 1887 to 1929 was a mechanism for reproducing cylinders, equipped with eartubes designed specifically for phonograph listening. Although it is possible to listen to early monophonic cylinders with complete assurance as to their truthful rendition (with due respect to their date of origin and present condition), better understanding and appreciation can be provided by a slightly different quality of sound for each ear. This improvement in auditory discrimination was offered by the Ediphone, the Edison cylinder business phonograph; a patent was then obtained on a method of improving auditory discrimination by a slight change in the phase of sound delivered to one ear from the transcribing machine.

Although highly sophisticated electronic devices have been added at times to the original disc and cup types of purely acoustical stethoscopes, the most prevalent method of auscultation in scientific medical diagnosis uses the acoustical stethoscope virtually unchanged since its invention in 1819. Edison adapted the stethoscope concept for evaluating phonographic recording even before introduction of his first commercial phonograph in 1888. The frequency range required for musical or voice sound recording differs from that required for analysis of the heart or other internal sounds, which accounts for the differences in tubing and earpieces used in early phonography.

The early wax cyclinders were really quite smooth and had considerable fidelity when heard through stethoscopic eartubes. The principal distortions usually associated with early recordings were generally the result of rapid wear or false resonances in reproducing horns, rather than in the way the records were cut. This in no way denies the tremendous improvements in techniques, but rather indicates the loss of idealisms in current approaches to sound recording.

That Edison understood acoustics, despite his deafness, is demonstrated not only by his invention of the phonograph in 1877, but also by a remarkable invention in the next year.[1] Edison's Megaphone demonstrated that for maximum discrimination each ear needs a separate and different collection of sounds; thus the first and perhaps the only accurate truly stereophonic listening device was produced.

If one channel of contemporary recorded sound may be considered the criterion of absolute fidelity, then the second may be used to supplement it by legitimate enhancement or variation. This will serve both the cause of historic accuracy and the cause of maximum communication and enjoyment. Contrast this with the impossibility of reducing sixteen channels of microphonic information (laden with many incompatible reflection and phase patterns) to two discreet channels of information which can be related to what one hears in the studio.

Several other problems arise from the uncontrolled electronic manipulation and amplification of sound. One problem is the misrepresentation of a weak voice as a strong one; but more grievous is the temptation to listen to reproduced music at levels far above those germane to the type of performance in question. Another problem is the use of headset equipment, either accidentally or purposely, to deliver levels of sound that may damage hearing—a problem which rightfully should concern libraries which use such equipment.

A great advantage of the direct acoustical recording process was its comparative immutability. A tenor who had a strong voice produced a comparable sound; one with a slight voice could not. It would have been impossible to present Mario Lanza as "The Great Caruso" in the acoustical recording era. A better acoustical perspective is possible on the relative vocal qualities of opera and concert artists who were recorded from 1902 to 1926 than those recorded since.

Eldridge R. Johnson was an engineer who showed his genius in business after being confronted with the problems of Emile Berliner and his crude gramophone. Johnson solved the basic problems of the gramophone, and adapted it to the innovation Edison had applied to cylinders—the solid wax blank for recording. Johnson also had the vision to see that recording the world's great solo artists exclusively and advertising regularly their Victor Records nationally, would open a potentially vast market for his improved shellac discs. Regardless of imperfections, time has proven that the performances of the eventually great galaxy of Victor artists were quite faithfully recorded, though inadequately reproduced by the Victrolas.

In less than a decade after the formation of the Victor Talking Machine Co. in 1901, Eldridge R. Johnson had proved how right he was—even to Edison. The latter finally acceded to the pleas of his business associates to produce a disc phonograph. Edison took charge of research, but determined that "The New Edison" must reproduce more faithfully than the Victor instruments.

From 1914 to 1927 the success of Edison's disc phonograph was demonstrated by an amazing series of public tests. Starting with a recital at Carnegie Hall in 1914, and later in numerous theaters and auditoria, artists recording for Edison played or sang, and then reproductions of their performances were played on an official laboratory model disc phonograph. In a number of these concerts the artist would be singing when the lights went out; suddenly, the lights would come on and a gasp would be heard, for the singer had left the stage and only the disc was playing.

The Edison standard laboratory model was sold by the thousands to the public. Records used in the artist/disc comparisons were not specially processed, but were the same ones as those in stock at the local Edison dealers. The criteria developed from the tone-tested Edison discs are used not only in the re-recording of the Edison discs, but, since many of the Edison artists also recorded for other companies, it is possible to correct the reproduction of these records. It has also been possible to extend use of the tone-test criteria back in time. For example, the reproduction of Edison cylinders before 1914, by the best cylinder-reproducing phonographs made at the time of recording or later, does not compare with the laboratory model disc reproduction of the same singer or instrumentalist, but can be adjusted to that quality in the re-recording process. Using other Edison criteria, the correct timbre of voice or instrument from such cylinder recordings as far back as 1902, making proper allowances for changes in age of vocal artist, etc., has been obtained in re-recording.

Unfortunately, the earliest recordings were on tinfoil sheets, once removed they were almost impossible to replace. Bernhardt recorded on them at the Edison Laboratory and a piece of foil in the Smithsonian Institution allegedly contains the voice of Kaiser Wilhelm. If such sheets exist undamaged, it may be possible to re-record them with techniques now available.

Commercial sound recording may be said to have begun in 1888 with the production of the white wax cylinder blanks for the improved Edison phonograph. Edison entrusted the first of these to his London representative, George E. Gouraud, who took them to England where he recorded the voices of several important Britons such as Prime Minister William Gladstone, poets Alfred Lord Tennyson and Robert Browning, and Florence Nightingale. The original "phonograms," as Edison called them, had a square bottom groove which produced some tracking difficulties, even though the reproducer was fed across the cylinder by a mechanical feed screw. In 1890 the shape of the groove was changed to a shallow groove, semicircular in cross section, but still one hundred grooves per inch. The composition of the records was changed, and cylinders of this type were made in colors from ivory to dark brown. They were called "originals" because the principal manufacturers did not have a commercial process for molding pre-recorded cylinders until 1902, and therefore, each cylinder was made as an original.

In 1900 the National Phonograph Company, owned by Edison, published *The Phonograph and How to Use It.*[2] On the basis of this book trying to re-record on the early cylinders is warned against even if the cylinder is successfully shaved. The evaporation of volatile oils, or oxidation of minor unsaturated material components has caused them to harden and become unsuitable for recording.[3] Most of the many thousands of fragile wax-type cylinders (white, ivory or light to dark brown) have been damaged by fungus. Examination of unplayed Columbia cylinders in their original cartons revealed that fungus spores first began growing where packers' fingerprints are found. Dampness is the greatest destroyer of wax-formula records, whether this type or the molded dark brown or black records produced by Edison, Columbia and other companies from 1902 to 1912.

The greatest service that can be performed in a belated effort to save the earliest sound recordings for posterity is to recommend that all archivists and librarians store such recordings in an absolutely dry environment. Experience has shown that air-conditioned, humidified storage is disastrous for Edison Diamond Disc records. At the Edison National Historical Site in West Orange, New Jersey, the problem was not with fungus, but with the gradual penetration of moisture into the cores, which were made of highly compressed wood flour, phenol gum and denatured alcohol, in about equal parts, with a small quantity of carbon black. The recorded surfaces were pressed or "printed," as the process is called, into a thin surface of condensite varnish—very smooth and hard. However, moisture apparently disrupts the smoothness of the core's surfaces and makes them noisy. From 1915 to 1920, Edison surfaces in the stores were often very noisy. Around 1921, a new process was introduced, with white labels, with inherently smoother surfaces. However, after long storage in an air-conditioned vault, these records also become noisy although never played.

Original-type ivory to brown wax records were also made from 1898 by Columbia, Edison, and one or two others in the grand or concert size records that were five inches in diameter. When found in smooth condition, free of fungus, these will deliver the best sound available prior to the molded cylinders.

All cylinders should be stored on their ends. Wax-type cylinders may be stored in boxes with cardboard tubes inserted in the bottom, much like those used in the early days. These permit free flow of air around the cylinders, with nothing in contact with the recorded surface. Cotton fleece-lined cartons which are dry and clean are good, but the atmosphere must be dry. As noted, these will deteriorate in an air-conditioned, humidified environment. While totally dry air is not best for the original cardboard containers, the important information is on the wax cylinders, and they should be stored at a relative humidity of 10 percent or less. It is best also, not to store the wax-type cylinders in sliding drawers, because they are susceptible to breakage by shock.

It is best to handle and clean cylinders only when they are at room temperature. They should be touched only on the ends or by putting the fingers inside. Since they become increasingly brittle over the years by evaporation of volatile oils or oxidation of minor unsaturated components, internal stresses have often built up and they will break just from the heat of the fingers, especially if they are cold. Gloves may help.

The last wax-type cylinders to be manufactured were the 200 grooves per inch Edison Amberol cylinders made from 1908 to 1912. These were extemely brittle from hardening ingredients added to the formula to facilitate their ability to withstand the increased unit pressure of a smaller sapphire stylus. These were succeeded by the Blue Amberol cylinders which were very durable and with which they should not be confused.

Many opera, musical comedy and vaudeville artists were recorded on the wax four-minute Amberols, including Lucrezia Bori, Maria Galvany, Leo Slezak, Alessandro Bonci, Sophie Tucker, and Sarah Bernhardt, who recorded excerpts of her most famous roles, none of the latter was ever transferred to the beautifully smooth, brilliant and durable Blue Amberol.[4] All of the molds of the Edison cylinders were literally shovelled from the vault at West Orange, New Jersey, some time after the death of Edison in 1931. As it had been Edison's lifelong policy not to abandon earlier customers when introducing either new instruments or new types of records, Thomas A. Edison, Inc., produced the Blue Amberol cylinders up until the end. In 1929, when production of musical records was discontinued by Edison himself, the company was producing the Diamond Discs and also laterally recorded discs, which Edison had reluctantly permitted his associates to produce.

Edison had been experimenting with celluloid for molding records prior to 1900, and had received a number of patents for various processes. However, a man by the name of Lambert was granted a patent in 1900 for a method which was first used for commerical production of molded cylinders. The Lambert records were made to fit the Edison mandrel of 1888, which had also been adopted by others, including Columbia. Therefore, it would have been most useful if it had been licensed to the larger producers, but in this country it was not. In England, Lambert records were issued by Edison-Bell, which also issued records of the same type. Lambert molded records were also made in England in the five-inch diameter size.

Lambert records were followed in the United States by Indestructible Records, of Albany, New York, under the Lambert and other patents. This record was produced with a stiffened cardboard insert with metal rings at each end inside the celluloid. Originally the Lambert records were a beautiful pink, later brown, and finally black when black became the color of molded wax cylinders.

Celluloid cylinders of all types were not susceptible to fungus, but the cardboard inserts of the Indestructible cylinders, and the plaster of paris linings of the Blue (and later Purple) Amberols, were often swollen and the records distorted from exposure to excessive dampness. The metal rings would also rust. The inside surfaces were protected by an asphaltic coating as were the edges of the Diamond Disc records. However, if humidified, air-conditioned storage, moisture will eventually penetrate almost any seal on the cylinders or laminated discs.

If the cores of the Blue or Purple Amerbols have not disintegrated, and the records are not ruined, they can be reamed out when dry by using an old mandrel with a handle attached at the shaft end, with medium coarse emory cloth wrapped smoothly around or glued to it. Care should be taken to remove only as much as necessary. By trying the record on a mandrel one can observe whether the surface is truly cylindrical and the core properly centered, so one may correct any eccentricity before it is too late.

John J. Thomas, engineering consultant for Syracuse University Audio Archives, constructed a precision lathe for doing this work which forces the exterior surface of the celluloid cylinder into the proper cylindrical shape; the cutting tool then removes exactly the right amount of material for a perfect fit. Unplayable Edison celluloid cylinders, or some which have pronounced bumps with every revolution, have been corrected by the Thomas lathe.

Cylinder records originally had information slips inside to identify what was on them. This practice was continued by Edison until about 1904. All cylinders were difficult to store and locate, and it was inconvenient to read the abbreviations of titles and artists around the rim, even after such labeling became universal.

It is important to note that Pathe in France was originally licensed by Edison and, prior to the introduction of molded records, had made many of the original-type cylinders in both standard and concert size. After molding was introduced, Pathe cylinders were made in three standard sizes: 1⅛-inch diameter, 5-inch diameter, and an intermediate size called the salon. The latter were very thin and fragile, yet many of the foremost Pathe artists were recorded on them. In the 1900s there were no less than a dozen companies making wax-type molded cylinders in France and England. Pathe had recording studios in a number of places, and Edison had a special series of recordings made in England, Germany, France and Italy by indigenous artists, many of importance. Lieutenant Bettini, who had recorded opera artists in his Fifth Avenue studio in New York prior to 1900, also produced molded cylinders in Paris, and recorded the voice of Pope Leo XIII in the Vatican.

Cleaning of wax-type records is tricky. It is recommended that one use a quantity of pieces of cotton velvet or velveteen about twelve to eighteen inches square. If a mandrel is removed from an old cylinder machine, a handle can be affixed to the feed shaft end to avoid warming the inside of the cylinder with the fingers. The cylinder should touch the mandrel all around at both ends and force should be avoided in putting it on. It is necessary to hold the handle so the record cannot slip off. A piece of velvet can be used gently to wipe off superficial dust or dirt, shaking the velvet frequently. Always use the same piece of velvet for this first step. Take another piece of clean velvet to wipe the grooves free of loose dust or dirt to uncover the fungus, if any exists; polish the record and remove dirt with the proper cloth for each step.

The next step is to apply a cleaner; Micro-Pel is recommended.[5] If the records are the four-minute wax Edison Amberol, Pathe Salon records or are known to be important, one should not spray the material directly on the cylinders, but on a pad of soft cotton cloth or velvet, wiping in the direction of the grooves. In spraying records directly, do so lightly all around being sure not to tilt the record downward as it might slip off the fingers or mandrel. In polishing, it is necessary to avoid catching the cloth on the record and pulling it off the mandrel, which is easy to do.

Although composition of the original wax records and molded wax records varied considerably from year to year, we have not found any wiping off or filling in of the high-frequency undulations by the use of spray. As yet, we have not tried it on the white wax records. Micro-Pel also works with celluloid records. The amount of material left on a record is not measurable, but renders the record slippery to the touch. (Do not touch the record grooves, however, especially on wax records.)

Celluloid cylinders can be stored in steel-case drawers on rollers. Storage in the original cartons is fine if clean and dry. Where cartons are missing, storage drawers may be specially prepared to hold the cylinders. The bottom of the drawer may be lined with fibreboard in which cardboard tubes have been inserted in an upright position to hold cylinders on end so they will not touch one another. Thus, complete catalog information slips can be inserted in the cartons or the supporting tubes.

The largest number of obsolete records are the 78 rpms, although this is a misnomer since few of the lateral disc records actually were recorded at that speed. Only Edison, in 1902, had the foresight to set an absolute fixed speed, at 160 rpm for musical cylinders, and in 1912, at 80 rpm for his discs. Many records were recorded at keys other than those in which they were originally written for various technical reasons, and concert pitches have varied from one part of the Western world to another, as well as having changed over the years.

The Edison Foundation Re-Recording Laboratory groups the original seven-inch diameter, Berliner single-side discs with the later, improved Berliner, Zonophone, Columbia, Victor and Gramophone records of the same size with paper labels and with shellac surfaces. The Columbias were laminated and should not be cleaned with water. This applies to nearly all Columbia records of various diameters through the years. The trouble Columbia had with surface noise was of much the same origin as the Edison discs and humidity was a principal culprit.

In cleaning the solid shellac stock records such as Victor's, we do not endorse or condemn washing with mild soap and water, if the labels are not wet. However, when records have been stored reasonably well over the years, the same procedure as described for cylinders, using various swatches of cotton velvet, is safer.

A major problem with used lateral-disc records is detritus, an abrasive dust created from the friction between the perishable steel, bamboo or tungs-tone styli and the V-shaped grooves, as a result of the abrasive materials mixed with the shellac to shape the stylus. The detritus not only dropped to the bottom of the groove, but was carried along by the stylus as it was shaped. After attempting various methods for cleaning many types of records, Micro-Pel seems as safe as any, especially after superficial dirt and dust have been removed. Often Micro-Pel facilitates passage of modern diamond styli quite well.

We are aware of styli with various degrees of truncation which permit bearing on an unworn position of a lateral groove, but feel this is really a job for an expert, involving microscopic analysis of both record and stylus. A reasonable choice of a spherical stylus will be practical and safe, where microscopic examinations and expert use of truncated styli are impractical.

All disc records should be stored on edge and in clean sleeves. We feel storage on steel shelving with frequent dividers to avoid leaning is best. This applies to solid shellac records, the laminated shellac records, and especially the outsize radio transcriptions which are up to twenty inches in diameter. The Pathe sapphire-ball discs were also molded in solid shellac and were made up to fourteen inches in diameter. European issues before 1920, had self-labels which were later paper. Since these were vertically recorded, they are especially likely to produce bumps and rumble from warping; they may also skip grooves at the slightest provocation, though usually without damaging the disc, except for tearing the label. Paradoxically, the earlier ones were center start, at a time when there were no paper labels.

An exception to storage in steel shelving might well be made in the case of 45 rpms and extended play records. Because of their light weight and the wastefulness of storage space on steel shelving, storage in file drawers is recommended, which also facilitates reading the smaller labels.

All plastic records of the period since LPs are best stored vertically. Cleaning is as for all other records but here the Micro-Pel seems to prolong high frequency life in use. At the convention of the Audio Engineering Society, April-May 1968, engineers with the RCA Princeton Laboratory reported on the use of the Scanning Electron Microscope to analyze and photograph the tracking and wearing problems of the LP and stereo discs.[6] This study showed convincingly that the present types of stereo discs, with lightweight tracking pressures and highly compliant cartridges, cause rapid demodulation of the plastic at the two limited points of contact in riding the groove, producing a furrow visible with a microscope after a single playing, and one visible to the naked eye after ten playings. Although we do not have an RCA Scanning Electron Microscope, a single light application of Micro-Pel to such records greatly increases the slipperiness and expedites the tracking of the stylus. As we know that friction of the diamond stylus against the unlubricated groove is appreciable, producing heat, and that it is lessened by the application of Micro-Pel, we may reasonably assume that the tendency to plow through the sides of the undulations in the grooves is proportionately reduced.

The final class of records of importance to libraries is that of acetates and lacquers. In the 1930s, acetate-coated aluminum discs superseded other methods for program recording. During World War II, the shortage of aluminum forced acetate manufactuters to use glass cores which were quite fragile, as the containing sleeves plainly said. Many important recordings both before and during the war were on such discs, which were often sixteen inches in diameter.

The application of the acetate to the aluminum or glass required castor oil, but eventually the oil was found to disassociate from the other substances, in some cases surfacing in a sticky mess which accumulates dust. Varying with formulation, storage conditions, etc., other acetate surfaces seem to shrink and peel away from the cores; little can be done in such cases.

Robert Carneal, recording engineer for the Library of Congress, devised a way of cleaning these sticky acetates by adapting the method for cleaning jewelry using ultrasonic vibration. Carneal used a tank large enough to hold the sixteen-inch discs, but used a more powerful agitation. He also protected the labels by covering them with rubber suction pads.

The only completely safe way to preserve information on the acetates, as with most media discussed here, is to re-record them. Specialists looking for information on the acetates may be interested in a report by Pickett and Lemcoe, *Preservation and Storage of Sound Recordings,*[7] which contains information about shellac discs, modern plastic discs and other recording tape available at that time. Surprisingly, it contains absolutely no information about cylinder recordings, but does have a bibliography of pertinent articles up to 1959.

Lacquer blanks are now used for recording, and are the contemporary substitute for the disc wax blanks used for masters from 1898 until the end of World War II. A duplicate of the lacquer master is often made from the master tape to send for approval to artists or persons contracting for custom-processed records. As such lacquers are quite soft, they will not withstand multiple playings, and, if valuable, should be re-recorded onto quality tape.

Although vinyl and other contemporary disc materials are much more durable than acetates or lacquers, they are not as hard as some earlier phonograph record materials. The only way to preserve the pristine excellence of any modern disc is to re-record it on high quality tape, as flat in fequency response as possible, before other use.

The life of magnetic tape is so far unkown. It is evident that tapes backed with cellulose acetate have a much shorter life than those backed by mylar and similar plastics. However, there are many factors, such as deterioration of adhesives, demagnetizing effects of long storage, and print-through. The recommendations of leading manufacturers about the best tape for long-term storage or for processing would be the best to follow.[8]

The ultimate form in which to preserve sound recordings indefinitely is to record anything considered worthwhile onto a disc. In producing a disc record, the metal mother—counterpart of the orginal wax or lacquer master—is plated to form a mold. The mold and mother are hermetically sealed by the plating process, and the metal parts are most predictably resistant for indefinite preservation against the ravages of time.

Articles on the shelving, care, and preservation of phonograph records appeared quite frequently during the long-playing record period of the 1950s. For various reasons there have been fewer since the introduction of stereo discs. In the catalogs of *Periodical Literature* and *Reader's Guide to Periodical Literature,* such articles will be found under "Care." In *Library Literature* they are listed under "Care and Preservation." In the *Music Index* they are under "Maintenance and Repairs."

Having reviewed the progress made in preserving and restoring the authenticity of sound recordings, it might be well to briefly comment on some early uses of phonography as a medium of research and education. For this, we must turn to developments in Europe. After Edison had entrusted to Gouraud the first improved Edison phonograph and a supply of the shaveable wax blanks which he used to demonstrate the potential of the new instrument, he sent other emissaries to Europe. One was Theodore E. Wangemann, a musician. Among others he recorded Brahms playing his famous *Lullaby*. The re-recorded remnant that is left of the Brahms *Lullaby* would hardly impress anyone today. The fact that Josef Hoffman as a boy prodigy wrote to Edison and obtained a phonograph and supply of cylinders about the same time indicates Edison was not indifferent to the potential of his new instrument for music and musicians.

In the more difficult fields of phonetic science, the anthropologists, philologists and ethnologists were the first to really appreciate the promise of this new medium. Armed with phonographs and blanks, recording expeditions from universities and museums in Europe and America collected recordings of various dialects: the chants, folksongs and legends of African tribes; and the patois and linguistic variants so rapidly changing due to increased travel and speed of communication. Before 1900, several recording expeditions had gone to Asia, Africa, South America, the western U.S. and Mexico. J. W. Fewkes, in May 1890, wrote about preserving the languages of the Indians, specifically the Passamaquoddy Indians in Maine.[9] Later, Francis Densmore began a collection of over 3,000 cylinders of Indian and early American folk music, some of which were later transferred for the Library of Congress to 78 rpm discs and later to LPs. A.L. Kroeber, a professor and secretary of the University of California's anthropological department, spent September 1906 among the Yurok Indians of North Humboldt County, producing one hundred Grapophone records of songs, myths and traditions.

In December 1906 similar activities were reported by Hans Pollak at the Academy of Science of Vienna.[10] Twenty-one cylinders of various German dialects had been gathered by J. Schulz and Park brought thirty-two native recordings from New Guinea. Evidently Vienna was a particularly active center, for Felix Exner, a meteorologist, was reported as recording sixty-eight Sanskrit songs while on a scientific expedition from there to India in 1904.

The relationship of Felix Exner to the Vienna physiologist, Sigmund Exner, is not revealed in the source by Pollak cited above. Pollak credits the idea of the archives to Sigmund Exner, who was then head of the Vienna Phonogram Archives Committee. As the official name of the Archives was Phonogramm-Archiv, the term phonogram suggests very clearly that inspiration for the idea probably grew from the visit to Vienna years before of Theodore E. Wangemann, Edison's earliest recording expert. It would be most fascinating to know exactly what happened. Edison coined the word phonogram to suggest transmission of messages in lieu of written correspondence—from the Greek "phone" meaning voice, and "gram" meaning that which is written.[11]

In any event, Pollak in 1925 reported on the special instrument being used in Vienna. He described it as the "Archive Phonograph," quite similar to Edison's. However, he said,

> The main difference is that the records are on discs and not on cylinders, but the instrument is no "gramophone," as the method of recording is

> Edison's; that is to say, the soundwaves are recorded in the thickness of the wax, and their ordinates are at right angles to the surface of the wax to which the oscillating diaphragm is parallel. By a galvanic process a copper "negative" is made and then nickelled over; and from this matrix, as many "positives" as wanted can be made.[12]

Since this article appeared in 1925, and Thoms A. Edison, Inc., had been producing disc records since 1912, it seems likely that the Archive Phonograph, using the basic Edison hill-and-dale system, was probably much like the Pathe disc process of similar derivation. The Pathe discs reproduced with a sapphire ball, as with the prior cylinders. Edison now was using diamond styli for both cylinders and discs.

The collaboration of other institutions with the Vienna Phonogram Archives is especially significant. Pollak said,

> The Archives have been much helped in the collecting of dialects by the allied institute at the University of Zürich, which has been energetically engaged in the work for some fifteen years. German, Provincal, Italian and Rhaeto-Romanic dialects have been systematically phonographed in Zürich, and permanent negatives made in Vienna from the records. The negatives are kept in Vienna, and the records can be heard in either Vienna or Zürich.[13]

This, then, was the world's first educational sound archives and reproducing center. How ironic it is that the academic linguists should have been so alert to recognize the potential of Edison's phonograph, while during the same years musical directors and professors of European music conservatories were ignoring it. Meanwhile, Eldridge R. Johnson and his brilliant Gramophone associates, to say nothing of their competition, were already recording the world's great vocal and instrumental artists.

The farsighted Exner had realized the only truly permanent storage for sound recordings was on hermetically sealed plates. This, as has been stated, is probably still true today. Despite the multitude of forms which have been developed for fixing sound, none is more assured of long life than the sealed metal matrices. Records in vaults are much more likely to withstand time unimpaired than are magnetic wire, tape, or sound-on-film, which may be either photographic or magnetic. Thus far, the homogeneous phonograph discs seem to be the best in the field of consumer recordings for longevity in use and in storage.

Continual changes in technology, with a bewildering number of options for storing and retrieving sound, are a greater threat to a library's efforts to make audio history available in a logical and sensible manner, than the loss of resources by attrition. We believe institutions of higher learning should assume a considerable role in determining the acceptable standards for sound recordings and reproducing practice—if not for reality in audio today, at least for truth in posterity.

Directors of music libraries, and schools of music and fine arts might well initiate a request to the Music Library Association, or any other truly representative group, to form a technics and standards committee to gather information about the various sound record-reproduce systems, to analyze durability of equipment and recordings in service, and to establish quality standards for recording, re-recording and reproduction. It would seem logical that this investigation might quite properly begin at the graduate and faculty levels of our schools of library science.

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